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Original Article

Staff Deployment Management System for the Aviation Industry. A cross-sectional Study of the Aviation Security Department at Entebbe International Airport, Uganda.

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Abstract

Background:

This study was undertaken to design and implement a Staff Deployment Management System (SDMS) that automates staff scheduling, deployment, monitoring, and reporting to improve workforce management and organisational performance.

Methodology:

The study adopted a qualitative case study research design involving 30 purposively selected participants, including security supervisors, shift leaders, administrators, and security personnel at Entebbe International Airport. Data were collected through interviews, observations, and document reviews to identify user requirements and existing deployment challenges. The collected data were analysed thematically to establish system requirements. The SDMS was designed using Context Diagrams, Data Flow Diagrams (DFDs), Entity Relationship Diagrams (ERDs), and a client-server architecture. The system was implemented using Python Django, HTML, CSS, JavaScript, SQL, and MySQL, and validated through unit, integration, system, and user acceptance testing.

Results:

The findings revealed that the existing manual deployment system was characterised by inefficient scheduling, staff absenteeism management challenges, communication delays, unequal workload distribution, inadequate emergency coordination, poor attendance tracking, and limited reporting capabilities. The developed SDMS successfully automated shift scheduling, staff allocation, attendance management, deployment tracking, notifications, reporting, audit logging, and role-based access control. System validation demonstrated improved deployment accuracy, transparency, accountability, operational efficiency, and decision-making while providing a scalable platform for future integration with other airport management systems.

Conclusion:

The implementation of the Staff Deployment Management System significantly enhances workforce deployment within the Aviation Security Department by eliminating inefficiencies associated with manual scheduling. The system improves transparency, optimises staff utilization, strengthens accountability, supports timely managerial decision-making, and contributes to enhanced aviation security operations through accurate and equitable staff deployment.

Recommendations

The formal adoption of the Staff Deployment Management System within the Aviation Security Department, supported by comprehensive user training and effective change management strategies.

Keywords: *Staff Deployment Management System, Aviation Industry, Entebbe International Airport.*
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Background of the study

In the industrial environment, information systems and technology use are critical to the advancement and support of industrial activities. (Zarlis, 2019). Staff deployment, also known as labor deployment or workforce deployment, is a challenging and time-consuming issue that needs to be resolved by any organization or business with employees who work irregular hours or shifts.

The definition of the workforce deployment problem is somewhat wide. The majority of research concentrates on flexible shifts with start times and assigning workers to shifts, as well as on figuring out working and rest days.
Dantzig (2002) proposed the first mathematical formulation of the problem based on a generalized set covering model. Several publications provide useful summaries of workforce deployment. According to Brucker (2010), the most

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researched application area in workforce deployment is nurse rostering.

Ant colony optimization (Seçkiner, 2008), dynamic programming (Elshafei, 2008), constraint programming (Qu, 2008), genetic algorithms (Dean, 2008), scatter search (Burke E. K., 2010), hyperheuristics (Remde, 2007), metaheuristics (Burke E. K., 2006), simulated annealing (Goodale, 2004), tabu search (Musliu, 2006), and variable neighborhood search (Burke E. K., 2008) are some of the recent and effective staff deployment algorithms.

The development of an automated work allocation system for security personnel at the Entebbe International Airport (EIA) aligns with the growing need for technology-driven solutions to support aviation security at the airport. By automating the manual process of allocating security personnel, aviation security can improve data management and security, addressing concerns similar to those highlighted by (Qurotul Aini, 2020). Moreover, effective workforce deployment is crucial for ensuring efficient airport operations and passenger safety, making this project a valuable application of the concepts as discussed in the introduction. By exploring workforce deployment algorithms and techniques, the Aviation Security (AVSEC) at Entebbe International Airport can optimize security personnel allocation, leading to Reduced time commitment for security personnel management, Improved operational efficiency through optimized resource allocation, increased transparency with electronic schedules, Reduced administration costs associated with printing and distribution of paper schedules, and enhanced airport security and passenger safety through optimized deployment of security personnel.

The East African Community Treaty requires partner states to harmonise their policies on civil aviation to promote the development of safe, reliable, and internationally compliant standards. Article 92 of the Treaty established the East African Community Civil Aviation Safety and Security Oversight Agency (CASSOA). CASSOA assists the partner states in meeting their safety and security oversight obligations. It also provides the partner states with an appropriate forum and structure to discuss, plan and implement common measures required for achieving safe and orderly development of international civil aviation through the implementation of international standards and recommended practices relating to civil aviation safety. (LUWEMBA, 2010)

Uganda is a signatory to the Chicago Convention on international civil aviation, and it is one of the five EAC partner states. It is therefore under an obligation to develop and implement international standards and recommended practices. It is required to ensure that there is an institution entrusted with the responsibility to ensure effective control and continued compliance with the established civil aviation standards within the scope of the country's civil aviation activities. To ensure that the safety system is appropriate and compliant with the established international standards, ICAO subjects each state to a repetitive five-yearly compulsory Universal Safety Oversight Audit Program (USOAP). A poor safety performance audit result is an indication of the need for an ineffective state's civil aviation security staff deployment management system. Therefore, this study developed a responsive Staff Deployment Management System for the Aviation Industry.

Methodology

Research design

A cross-sectional study research design was employed in the investigation.

Research approach

The study employed a qualitative research approach. Qualitative research is a method of investigation that focuses on understanding the "why" and "how" of phenomena, rather than just measuring the "what" or "how much" (Bazen, Barg & Takeshita, 2021).

Area of study

The study was carried out at Entebbe International Airport, Uganda, Wakiso District, under the Aviation Security (AVSEC) Department.

Study Population and Sample Size

The study targeted a total population of 30 participants, including Security Supervisors, Shift Leaders, Security Personnel, and administrators/Managers. In qualitative research, sample size determination isn't based on statistical power or calculations, but rather on achieving a balance between depth and breadth of data (Redd & Pulluru, 2024). On the other hand, the qualitative sample consisted of at least 30 key respondents.

Sampling technique(s)

Purposive sampling

Creswell (2014) suggests being purposeful in identifying participants that might provide insight into your research question. Purposive sampling involves selecting participants because the researcher believes that they might contribute something to the study's analysis of data.

Data Collection Methods and Instruments

The study adopted interview and observation methods.

Interview

The interviews were conducted with the aviation security department deployment officers, supervisors, and systems administrators. The interview method allowed on-the-spot explanations during the data collection process and through respondents' facial and body expressions, tone of voice, gestures, feelings, and attitudes. Here, the researcher was able to get rich information on the current way of deploying security staff and the system being used for staff rostering.

An interview guide was generated as a tool to guide the data collection process.

Observation

This method was used since it allows the researcher to see what is done directly without relying on what people say. It was used because it provides data that people may hide. (Luh Sari Damayanti, 2019). The researcher physically observed day- today staff deployment and other related deployment security staff operations, which enabled the gathering of the right information. An observation guide as an instrument will be prepared to aid the process.

Data Quality Control

Validity of the data collection tools

Validity of data collection instruments an essential need that the researcher didn't ignore. The instruments which were used to collect data were examined, and eventually approved as thorough enough to transform collected data into a format that can be used to construct a good deployment system for the aviation security department.

Data Collection Procedures

In order for the researcher to collect data from the field, an introductory letter was obtained from the University of Kisubi, which was taken to the aviation security department at Entebbe International Airport, where data was collected. Upon acceptance by the aviation security department to carry out the study, the researcher was able to select respondents, seek their consent, and carry out the data collection.

Data Analysis

After collecting the data from the field, the researcher analyzed and extracted the required information. The collected data was categorized and cleaned, then explanations were made about the data using thematic Analysis. The researcher identified the requirements for the development of the staff deployment system for aviation security.

System Implementation

Python Django Framework: A high-level Python web framework following the MVC pattern was used to handle the backend logic, data management, and API endpoints. JavaScript was used to enable dynamic and interactive user experiences in web browsers. It manipulates the DOM, handles events, and communicates with the backend API. HTML Markup language for creating the structure and content of web pages. Defines elements, tags, and attributes used to organize information. CSS Stylesheet language for describing the presentation and styling of web pages will be used to control the layout, colours, fonts, and visual aspects of HTML elements. SQL (Structured Query Language) was applied for managing and manipulating relational databases. It provides commands for creating, querying, updating, and deleting data. Integration and Workflow: Django served as the backbone, handling backend logic and data management.

System Testing and Validation

The individual modules of the system were tested using the available data to ensure that the system is functional. The system was exposed to the users to test its usability and its usefulness for staff deployment at the aviation security department.

Limitations of the Study

The researcher anticipated facing the problem of the unwillingness of the respondents to provide information, since some information was considered confidential and very sensitive for security.

Research Ethical Consideration

The researcher obtained written permission from the School of Graduate Studies and Research to access the aviation security department at EIA, where the data was collected. The names of interviewees did not appear anywhere in this report, and any information obtained was agreed upon with the interviewees before using it. Before starting the interview, respondents were told that the information recorded was purely academic and confidential.

Results

Analysis of Aviation Security Department role.

The majority of responses describe roles focused on supervision, deployment, and monitoring of staff and security operations at Entebbe International Airport. Many respondents identify themselves as supervisors, duty officers, or checkpoint supervisors. There's a clear hierarchical structure implied in the responses. Notable trends were that there is a significant number of individuals in supervisory roles. The descriptions often lack detail regarding specific tasks, focusing instead on broad responsibilities (e.g., "supervise," "monitor," "deploy"). One respondent highlights a training role, indicating a diverse range of functions within the department. The findings do not provide information on the size of the department, the overall organizational structure, or the specific security procedures followed.

"*There's no information on the level of training or experience required for each role.*" A key respondent explains.

Analysis of Staff Deployment Responsibility

An important insight from the study is the presence of roles beyond regular security duties, including capacity-building functions. As one respondent noted,

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"I am often involved in training new recruits and conducting refresher courses, in addition to my daily shift duties."

This statement reflects a blending of operational and training responsibilities, suggesting that some staff take on dual roles, which may complicate straightforward deployment planning. The responses overwhelmingly focus on the practical aspects of staff deployment. Most respondents describe their roles as involving:

Deployment: Physically assigning staff to specific checkpoints or tasks.

Supervision: Monitoring staff performance, ensuring adherence to procedures, and addressing problems.

Briefing: Communicating instructions, updates, and relevant information to staff.

Resource allocation: Balancing staffing levels across different checkpoints based on need and personnel availability.

Oversight: Ensuring that the initial deployment plan is followed and that all areas are adequately covered.

Methods of staff current deployment

The overwhelming majority of responses describe a manual, paper-based system for staff deployment. There's a strong emphasis on factors like staff capability, seniority, gender balance, and workload distribution when assigning staff to different roles or locations. Many respondents highlight the challenges of this manual system, including fatigue from repetitive assignments and the difficulty of ensuring fair workload distribution. The study noted that deployments are frequently reactive rather than proactive. For instance, shifts are adjusted in response to urgent events, absenteeism, or emerging security concerns without a clear backup plan. As one staff member observed,

"Sometimes you just wait to be told where to go when there is an emergency or a shortage; it depends on who is available."

Analysis of Security Staff Deployment Challenges

The overwhelming majority of responses highlight staff absenteeism as the primary challenge in effectively deploying security personnel. Other recurring themes include: A shortage of staff relative to the number of checkpoints or required tasks. This is often exacerbated by absenteeism. Reliance on manual systems (paper rosters) leads to time-consuming deployments, errors (repeated assignments, omissions), and difficulty tracking staff assignments.

"Most of the time, we rely on printed lists pinned to the wall. If changes occur, we have to cross them out or rewrite everything," reported one deployment officer.

Analysis of Responses to Emergency Handling Question

The assessment of responses from aviation security personnel on the issue of emergency handling reveals notable trends in both awareness and operational preparedness within the department. Emergency handling, being a critical aspect of aviation security, requires a coordinated, prompt, and well-documented response mechanism. However, the findings indicate a combination of strengths and gaps.

Awareness of Emergency Protocol

Most respondents showed general familiarity with the existence of emergency procedures. They recognized the importance of immediate action in situations such as bomb threats, fire outbreaks, or unauthorized access.

"We are usually instructed to notify the control room and follow the standard operating procedures," said one officer.

However, this awareness appears to be more theoretical than practical for some staff, suggesting inconsistencies in training and practical exposure.

Inadequate Emergency Drills and Training

The majority of staff members indicated that drills are not frequently conducted, and when they are, participation is limited to specific groups or roles.

"I've been here for over a year and have never been part of any emergency simulation," shared a junior officer.

This suggests a lack of structured and inclusive training programs, which may compromise real-time response capacity.

Manual Communication and Delayed Response

Several respondents noted that communication during emergencies is often delayed due to the reliance on manual reporting methods such as phone calls or face-to-face alerts.

"In case of an emergency, I have to move to the supervisor's office or call using personal contacts, which takes time," one respondent observed.

This manual approach increases response time and can lead to confusion, particularly during large-scale or fast-developing incidents.

Lack of Standardized Emergency Roles

Some personnel admitted that there is limited clarity about individual roles during emergencies. While procedures exist, not all staff are certain of their specific responsibilities.

"During an incident, we sometimes wait for orders instead of acting promptly because we don't know

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who is responsible for what," stated a senior officer.

This reflects the need for clearer role assignments and role-based training during emergencies.

No Formal Debriefing or Feedback Mechanism

Responses revealed that there is generally no structured review or reporting mechanism after an emergency has been handled.

> *"Once the situation is handled, that's it. We don't sit down to discuss what went wrong or what we could do better," said a supervisor.*

This lack of a feedback loop means that lessons from past incidents are not captured or used to improve future preparedness. Thurs the analysis underscores a significant need for structured emergency preparedness programs, including regular training, clearly defined roles, real-time communication tools, and post-incident evaluations. Integrating an emergency management feature in the proposed Staff Deployment Management System would enhance response efficiency and support documentation and coordination during critical incidents.

Analysis of Staff Deployment Strategies.

Effective staff deployment is essential for maintaining robust security operations at an international airport. This study analyzed the current deployment strategies used within the Aviation Security Department at Entebbe International Airport, revealing a blend of formal procedures and informal adaptations influenced by staffing levels, shifts, and operational needs.

Shift-Based Rotational Deployment

The most commonly adopted strategy is shift-based rotational deployment, where staff are scheduled to work in rotating shifts: morning, afternoon, and night. This approach ensures 24-hour surveillance and guards against fatigue.

> *"We follow a weekly shift schedule, but changes happen depending on who is available," noted one respondent.*

While this method offers continuous coverage, the manual scheduling process often results in inconsistencies, especially when last-minute changes occur due to absenteeism or emergencies.

Deployments are mostly managed manually using paper records or spreadsheets. This results in time-consuming updates and a higher risk of error.

> *"The deployment book is in the office. If a mistake happens, we correct it with a pen," one respondent shared.*

Lack of automation also impedes efficient tracking of staff movements and performance.

Analysis of Security Staff Deployment Practices and Morale

The study findings indicate that deployment is primarily handled through manual scheduling, often directed by supervisors based on experience, post requirements, and immediate operational needs. However, the lack of a systematic digital approach results in frequent scheduling conflicts and inconsistencies.

> *"Sometimes, we don't know our exact shift until the day before. It makes planning difficult," said one officer.*

Such unpredictability in deployments has contributed to decreased morale among some staff members who feel undervalued or overworked due to inconsistent shift allocations.

There is Overdependence on Supervisory Discretion. Many respondents cited that deployment decisions are largely made at the discretion of a few senior supervisors. While this approach is responsive to real-time demands, it introduces elements of favoritism and inequitable workload distribution.

> *"There are some posts people don't want, and the same officers get assigned there again and again," one respondent noted.*

This has led to perceptions of unfair treatment, affecting motivation and job satisfaction.

Some personnel are consistently assigned to specific posts without rotation, while others are frequently moved across different posts. Though this ensures operational familiarity for some, it can lead to boredom or burnout due to repetitive tasks or stress from unfamiliar roles.

> *"You get used to one area, and then suddenly you're placed at the entrance gate with no briefing," an officer expressed.*

This inconsistency undermines staff confidence and morale, especially when support or training is lacking.

Inadequate Recognition and Feedback is another issue that came up. Deployment practices appear to focus solely on physical presence and role filling rather than performance evaluation or staff recognition. Respondents reported a lack of feedback on their work and minimal reward or appreciation for good performance.

> *"We are expected to be alert all day, but there's no thank you or recognition unless something goes wrong," shared a long-serving officer.*

The absence of an incentive or reward system contributes to a sense of underappreciation, which demotivates staff over time.

Overall, the morale of staff is closely tied to how fairly and transparently deployment is managed. When deployment is seen as biased or poorly planned, staff are less committed, more likely to be absent, and less responsive to critical situations.

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"If I knew my work was valued and scheduled fairly, I'd be more committed," one respondent said.

Analysis of Deployment Practices and Productivity

Manual Deployment and Administrative Inefficiencies: The current deployment practices are largely manual, involving the use of printed rosters, verbal briefings, and handwritten schedules. This approach often results in duplication of tasks, delays in communication, and deployment conflicts.

"Sometimes, officers report to a shift only to find that two people were deployed for the same post," revealed a shift supervisor.

These inefficiencies reduce the productive use of human resources, leading to idle time or overstaffing at specific checkpoints.

Lack of Real-Time Allocation is another challenge. There is no real-time system for monitoring or adjusting staff deployment based on dynamic airport activity levels. As a result, staff may be underutilized during low-traffic periods or overwhelmed during peak times, without a quick way to redistribute personnel.

"During busy hours, we sometimes find ourselves short-handed because the shift plan didn't anticipate a crowd," a respondent noted.

This mismatch between deployment and actual demand reduces productivity and increases response time in critical situations.

Absenteeism and Unmonitored Performance: Due to the absence of a centralized deployment system with attendance tracking, absenteeism and late reporting are common and often go unnoticed until it affects operational flow. This directly impacts productivity as tasks are redistributed to already burdened officers.

"If someone doesn't show up, the rest of us have to cover, which means more standing hours and less alertness," one officer remarked.

Additionally, with no system to track individual output, evaluating staff performance based on deployment effectiveness is nearly impossible.

Officers often receive non-specialized assignments, regardless of their skills or prior experience. This leads to inefficiencies, as staff may take longer to execute tasks they are unfamiliar with or may not perform optimally.

"I've been trained in baggage scanning, but I'm rarely assigned there. Instead, I do gate checks where my skills are underutilized," explained a trained operator.

The misalignment of skills and deployment roles reduces both individual and overall team productivity.

Lack of Feedback and Improvement Mechanisms: Current deployment practices do not integrate structured feedback loops to evaluate their impact on performance. There is no formal review of daily or weekly deployment plans, making it difficult to identify patterns of underperformance or areas needing support.

"We are just told where to go. No one asks how the shift went or whether the deployment plan worked," said a respondent.

Without data collection or evaluation, there's no opportunity for continuous improvement in deployment planning and execution.

Analysis of Airport Deployment System Security Responses

The overwhelming majority of responses highlight the contribution of the current deployment system to airport security standards through adherence to Standard Operating Procedures (SOPs) and the implementation of gender balance in staff assignments. Many responses mention the deployment of supervisors and consideration of staff capabilities and training. There's a strong emphasis on SOPs as the foundational element ensuring security. Gender balance is consistently cited as a crucial component of the system, reflecting sensitivity to passenger needs and security protocols. However, a few responses subtly hint at shortcomings in the system's effectiveness, suggesting a gap between stated procedures and actual practice.

"Sometimes deployment details are shared in group chats, which is not secure at all," noted one respondent.

Analysis of Security Coverage Responses

The overwhelming majority of responses indicate that insufficient security coverage is a more frequent problem than excessive coverage. The primary reason cited for insufficient coverage is staff absenteeism (sick leave, no-shows).

"At times, we're just assigned based on who's available, not necessarily where security risk is highest,"

commented a supervisor. Other contributing factors include peak hours and emergencies. There's a strong consensus on the methods used to address insufficient coverage: re-deploying staff from less busy areas to those requiring more manpower ("doubling up efforts," "shifting staff," "rotating stuff"). The use of CCTV as a supplementary measure is also mentioned. While some respondents acknowledge situations with excessive manpower (often due to staff returning from leave or training), these are viewed as less common and generally manageable by re-deployment.

Challenges in Maintaining 24/7 Coverage: Several challenges were noted, such as fatigue, absenteeism, and poor coordination. These issues reduce the effectiveness of continuous surveillance and weaken response capability during emergencies.

"Sometimes we are not enough, especially for night shifts. We end up rotating the same people," said one respondent.

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This shows the need for an automated scheduling system that factors in shift balance, staff rest periods, and workload rotation.

Perception of Deployment Effectiveness: When asked whether the current deployment strategies ensure effective coverage, responses were mixed. Some personnel believe the system works under normal circumstances, while others pointed out that it is inefficient during emergencies or high-traffic periods.

> *"Deployment works on a good day. But during peak hours or an incident, we're spread too thin," one officer admitted.*

This emphasizes the need for a flexible and scalable system that can quickly reassign staff during dynamic situations.

Analysis of Technology's Role in Improving Deployment Process

Current Use of Technology in Deployment: Findings indicate that the current staff deployment process is predominantly manual, involving printed duty rosters, phone calls, and spreadsheets. While some offices may use basic digital tools (such as Microsoft Excel), there is no centralized system to manage real-time assignments, track staff presence, or adapt to sudden changes.

"We still depend on printed rosters pinned on the noticeboard," one respondent reported.

This manual approach lacks flexibility, efficiency, and visibility—factors critical in a high-risk, fast-paced airport environment. Respondents cited several inefficiencies:

i) Difficulty updating and disseminating rosters quickly.
ii) Inability to monitor on-duty staff in real-time.
iii) Absence of historical deployment data for audit or performance evaluation.
iv) Delays in emergency redeployment due to communication breakdowns.

These challenges highlight the urgent need for digital transformation in the department's deployment practices.

Analysis of the suggested Staff Deployment Management System Features

The study explored the perspectives of security personnel and administrators at Entebbe International Airport regarding the proposed Staff Deployment Management System (SDMS). Respondents shared their expectations and feature suggestions for a computerized system that would streamline the current manual deployment process. Below is an analysis of the key features recommended and their implications for system design and implementation.

One of the most highly requested features was automated shift deployment. Respondents emphasized the need for the system to:

Automatically generate duty rosters.
Ensure fair shift rotation.
Minimize human bias and fatigue by distributing workloads equitably.

"The system should generate shifts based on availability and fairness, not just manual input," one officer noted.

Another key feature suggested was the real-time monitoring of personnel on duty. Respondents wanted a dashboard that shows:

Who is currently on duty.
The specific deployment location of each staff member.
Staff who are on leave, standby, or absent.

This functionality is crucial for effective supervision and quick redeployment during emergencies.

Such automation would improve transparency and help maintain morale among security staff. Requirements Identification

Functional Requirements

Shift Deployment and Management

i) The system shall allow supervisors to create and assign shifts (daily, weekly, or monthly).
ii) The system shall prevent deployment conflicts such as overlapping or double shifts.
iii) The system shall allow staff to view their upcoming shifts.

Deployment Allocation

i) The system shall enable automatic or manual assignment of staff to specific areas (e.g., terminals, baggage screening, gates).
ii) The system shall consider staff availability, qualifications, and workload when assigning duties.

Non-Functional Requirements

User Authentication and Access Control

i) The system shall allow users to log in with a unique username and password.
ii) The system shall support role-based access for administrators, supervisors, and security staff.

Staff Profile Management

i) The system shall allow administrators to create, edit, and deactivate staff profiles.
ii) Each profile shall include personal information, position, qualifications, and shift history.

Notifications and Alerts

i) The system shall send automated notifications to staff for new shift assignments or changes.
ii) The system shall alert supervisors in case of unassigned posts or last-minute staff absences.

Attendance Tracking

i) The system shall generate attendance reports.

Leave and Absence Management

ii) The system shall allow staff to apply for leave.
iii) Supervisors shall be able to approve or reject leave requests.
iv) Approved leaves shall be factored into shift planning.

Reporting and Analytics

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i) The system shall generate reports on deployment trends, shift coverage, overtime, and absenteeism.
ii) The system shall allow exporting reports in PDF or Excel formats.

Audit Trail and System Logs

i) The system shall maintain a log of all user activities for accountability and security.

Discussion

System Architecture

The system follows a client-server architecture, where users interact with a web-based interface (client) that communicates with a centralized database and server for processing.

Client Side: Users access the system via web browsers.

Server Side: Business logic and database management are handled on the server.

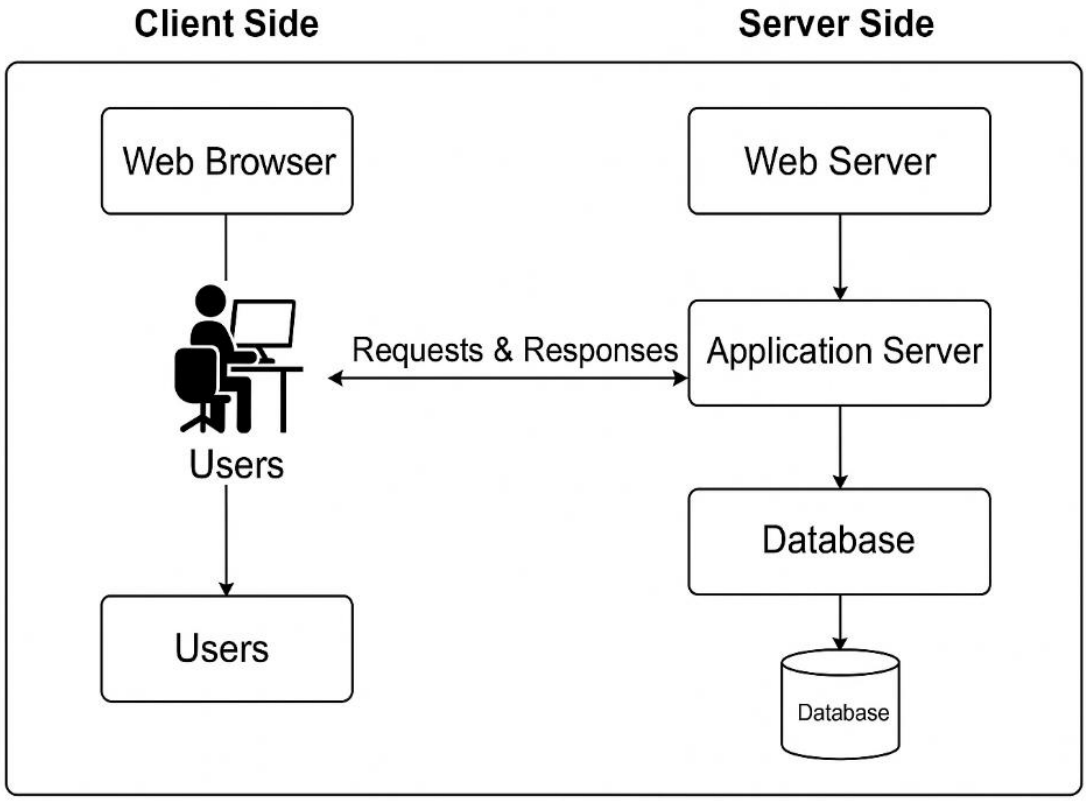

Figure 1: System Architecture; Client and Server Side

In the Application Layer (Business Logic Layer) the Core Modules Include: Shift Management Module to create and manage shifts, Deployment Module to assign staff based on availability, roles, and priority areas, Attendance & Leave Module to track attendance, manage sick leave or other absences, Notification Module to send alerts or reminders about new assignments or changes and Reporting & Analytics Module for Generating deployment, absenteeism, and performance reports.

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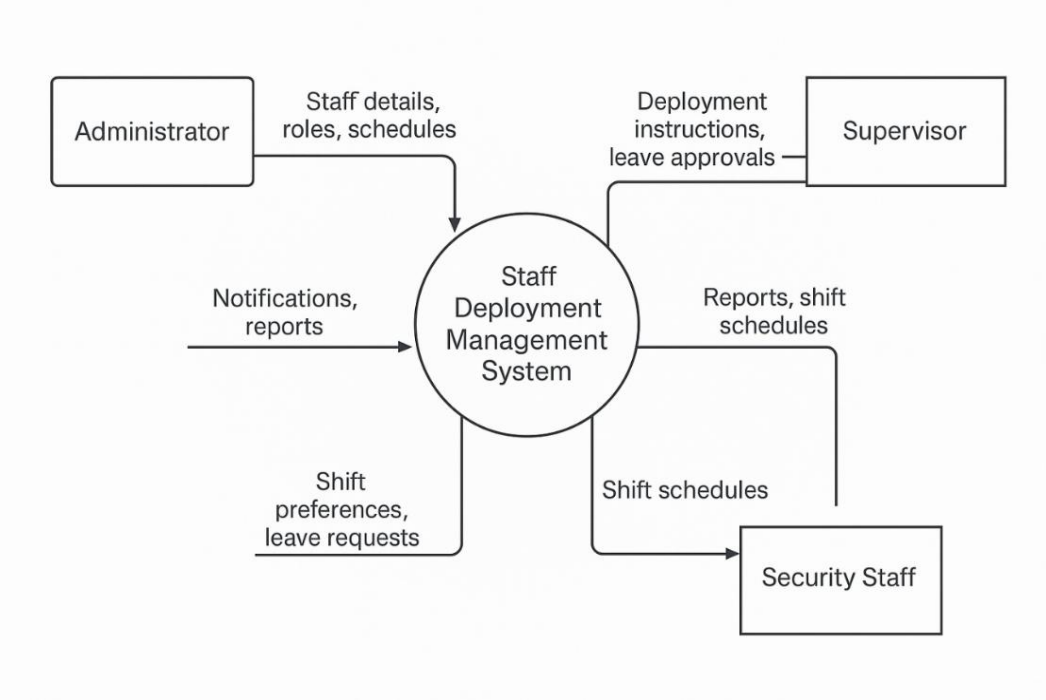

Figure 2: Context Diagram: Data Flow Diagrams (DFDs) for Staff Deployment Management System

Main components: External Entities include: Administrator, Supervisor, Security Staff, and the system.

Staff Deployment Management System

Data Flows:

i. Administrator → (Staff details, roles, deployment) → System
ii. Supervisor → (Deployment instructions, leave approvals) → System
iii. Security Staff → (Shift preferences, leave requests) → System
iv. System → (Notifications, reports, shift deployments) → All users

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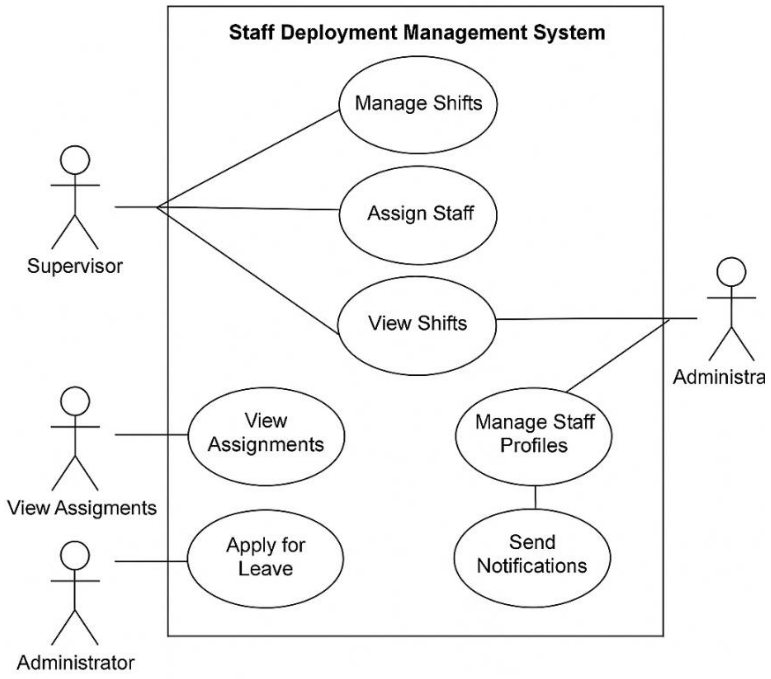

Figure 3: Use Case for Staff Deployment System

The Use Case Diagram above visually represents how different users (actors) interact with the Staff Deployment Management System. Here's a breakdown of its key components and their meanings:

Actors

These are the external entities (usually users) that interact with the system:

Administrator – Manages system settings, users, and overall deployment processes.

Security Supervisor – Assigns staff to shifts, generates reports, and monitors deployments.

Staff Member – Views personal schedules and receives notifications.

HR Officer – Manages staff records, tracks attendance, and training.

The Specific functionalities or tasks the system offers:

Login / Logout – Secure access control for users.

Manage Staff Records – Add, update, and delete personnel information.

Assign Deployment – Allocate staff to specific tasks or areas.

View Deployment Schedule – Staff view their assignments.

Generate Reports – Supervisors or admins analyze deployment trends or history.

Track Attendance – Monitor who reports for duty.

Send Notifications – Alert staff of shifts, changes, or emergencies.

View Emergency Protocols – Accessible by relevant actors for quick response.

Audit Logs – Review system activities for security and transparency.

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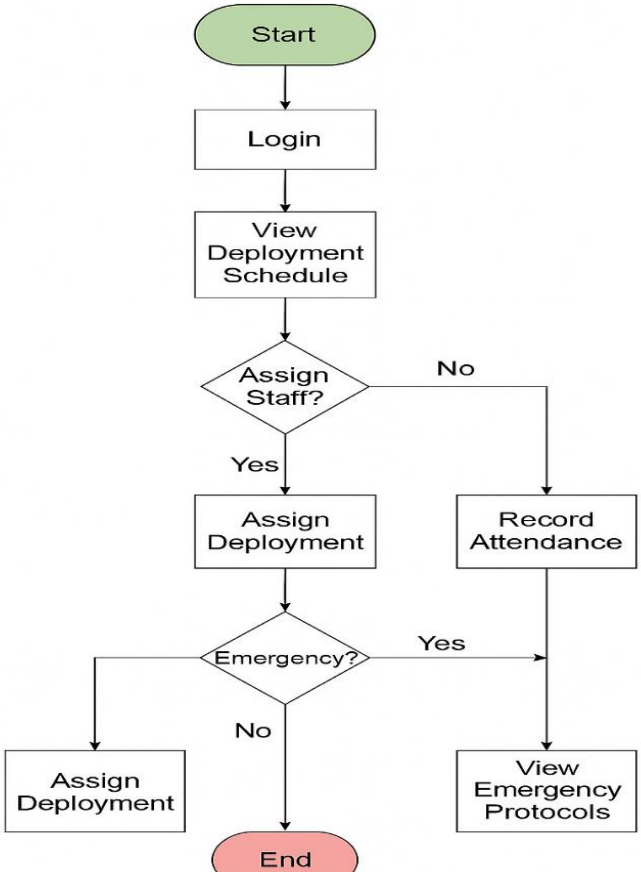

Figure 4: Activity Diagram for Staff Deployment System

The Activity diagram above illustrates the key processes of the **Staff Deployment Management System**. Here's an explanation of each component:

1. Admin Login

i) The process begins with the system administrator logging in to access system features.
ii) The system checks credentials before granting access.

2. Staff Registration

i) Once logged in, the admin can register new security staff members.
ii) This includes entering personal data, contact details, and assigning roles.

3. Shift Scheduling / Staff Deployment

i) After registration, the admin schedules staff by assigning them to various duty stations and shifts.
ii) Scheduling is likely based on staff availability, department needs, and qualifications.

4. Emergency Deployment

i) In case of an incident or unexpected absence, the system allows for rapid deployment of available staff.
ii) This ensures quick response and continuity of operations.

5. Monitoring and Supervision

i) Supervisors or admins can monitor staff attendance, duty performance, and station coverage.
ii) May include logging incidents or feedback.

6. Reporting

i) The system generates reports, such as:
ii) Daily/weekly deployment schedules
iii) Staff attendance logs
iv) Incident summaries
v) Performance evaluations

7. Logout

i) Admin logs out of the system after operations are complete.

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Database Design

1. Staff Table

Field Name	Data Type	Description
staff_id	INT (PK)	Unique ID for each staff member
first_name	VARCHAR	Staff's first name
last_name	VARCHAR	Staff's last name
gender	VARCHAR	Male/Female
department	VARCHAR	Department assigned
position	VARCHAR	Job title or position
contact_number	VARCHAR	Phone number
email	VARCHAR	Email address
status	VARCHAR	Active/Inactive

2. Deployment Table

Field Name	Data Type	Description
deployment_id	INT (PK)	Unique ID for each deployment
staff_id	INT (FK)	Staff assigned
location	VARCHAR	Deployment location
shift	VARCHAR	Day/Night shift
date_assigned	DATE	Date of deployment
supervisor_id	INT (FK)	Supervisor in charge
status	VARCHAR	Active/Completed

3. Supervisor Table

Field Name	Data Type	Description
supervisor_id	INT (PK)	Unique ID for each supervisor
name	VARCHAR	Full name
contact number	VARCHAR	Phone number
email	VARCHAR	Email address

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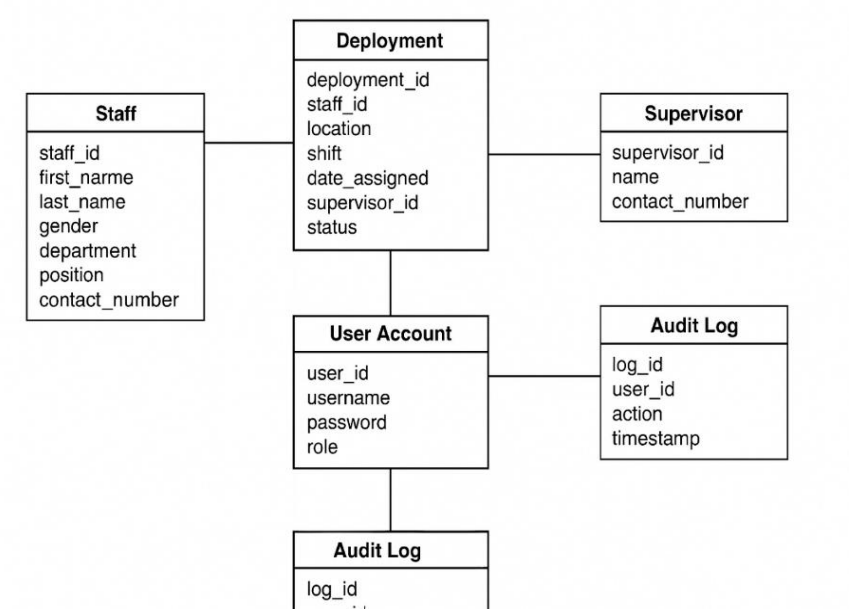
4. User Account Table

Field Name	Data Type	Description
user_id	INT (PK)	Unique ID for each user
username	VARCHAR	Login username
password	VARCHAR	Hashed password
role	VARCHAR	Admin, Supervisor, Staff
status	VARCHAR	Active/Inactive

5. Audit Log Table

Field Name	Data Type	Description
log_id	INT (PK)	Unique ID for each log
user_id	INT (FK)	User who performed the action
action	VARCHAR	What was done
timestamp	DATETIME	When it occurred

Fig. 5: *Shows Database Design*



Implementation Tools and Technologies

i. Frontend: HTML, CSS, JavaScript (Bootstrap for design)
ii. Backend: PHP or Python (Flask/Django)
iii. Database: MySQL
iv. Server: Apache (via XAMPP/WAMP)
v. IDE: Visual Studio Code
vi. Version Control: Git (optional but recommended)

System Testing

i. Unit Testing: Tested individual modules like login and shift assignment
ii. Integration Testing: Ensured modules work together
iii. User Acceptance Testing (UAT): Conducted sessions with sample users from the aviation security team

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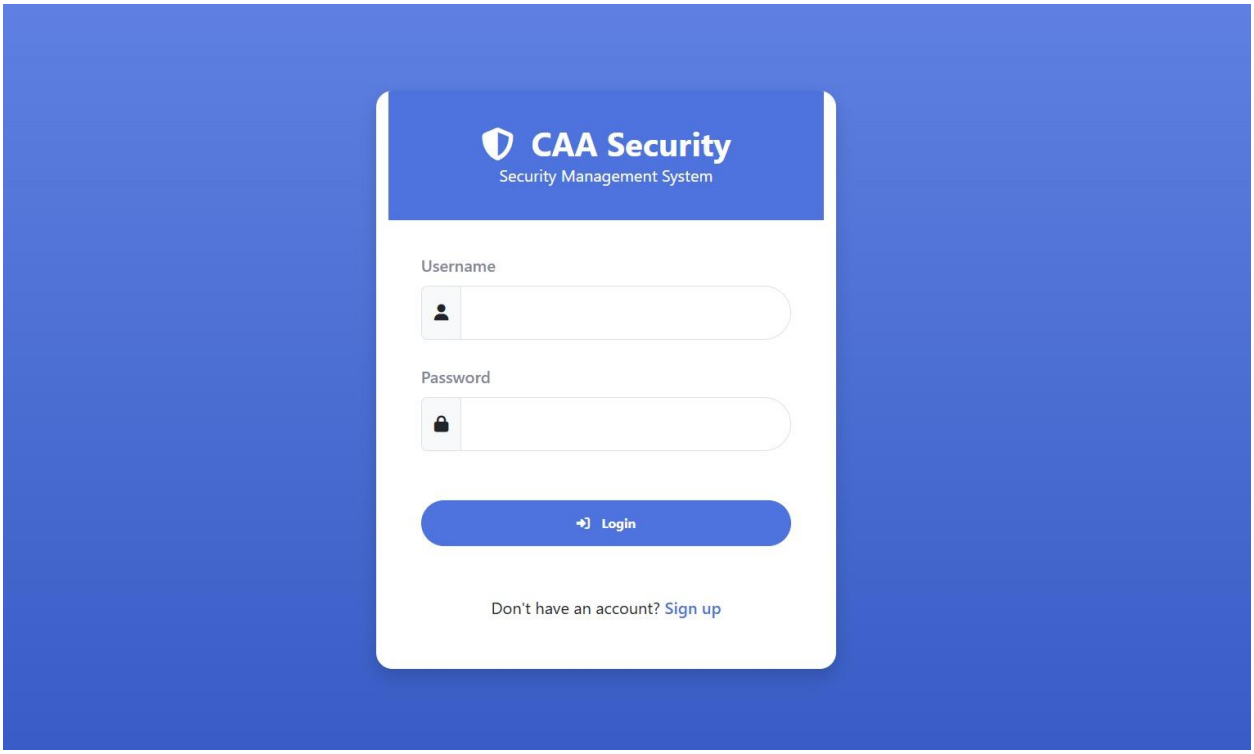

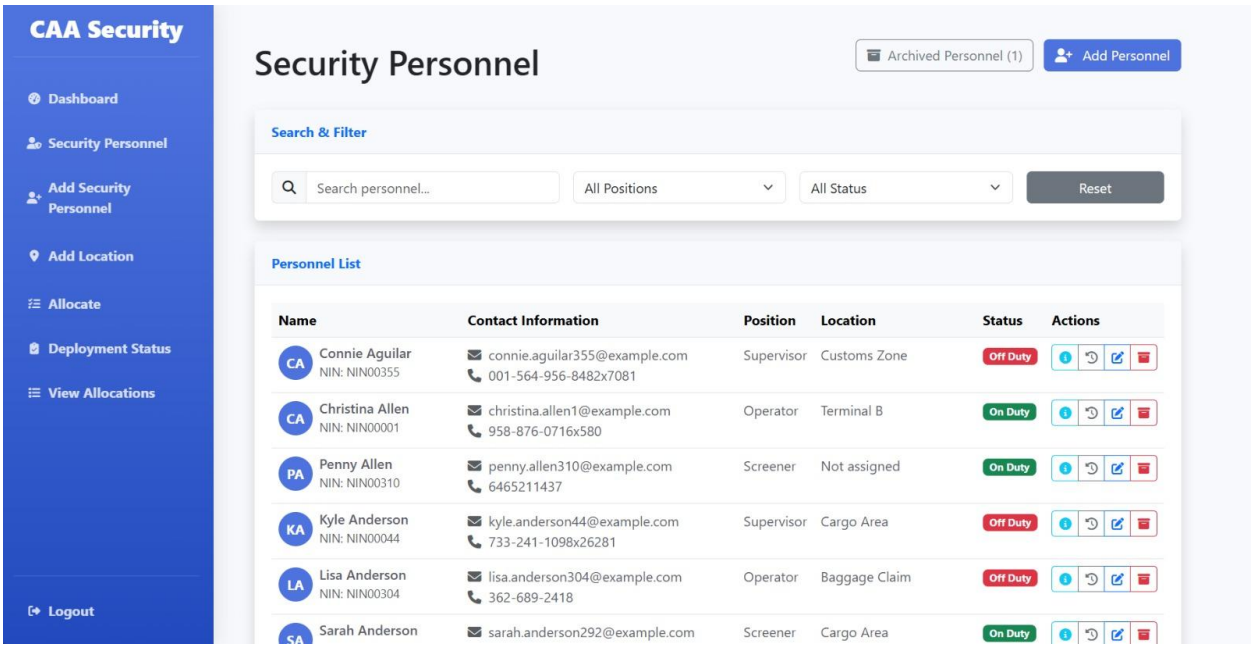

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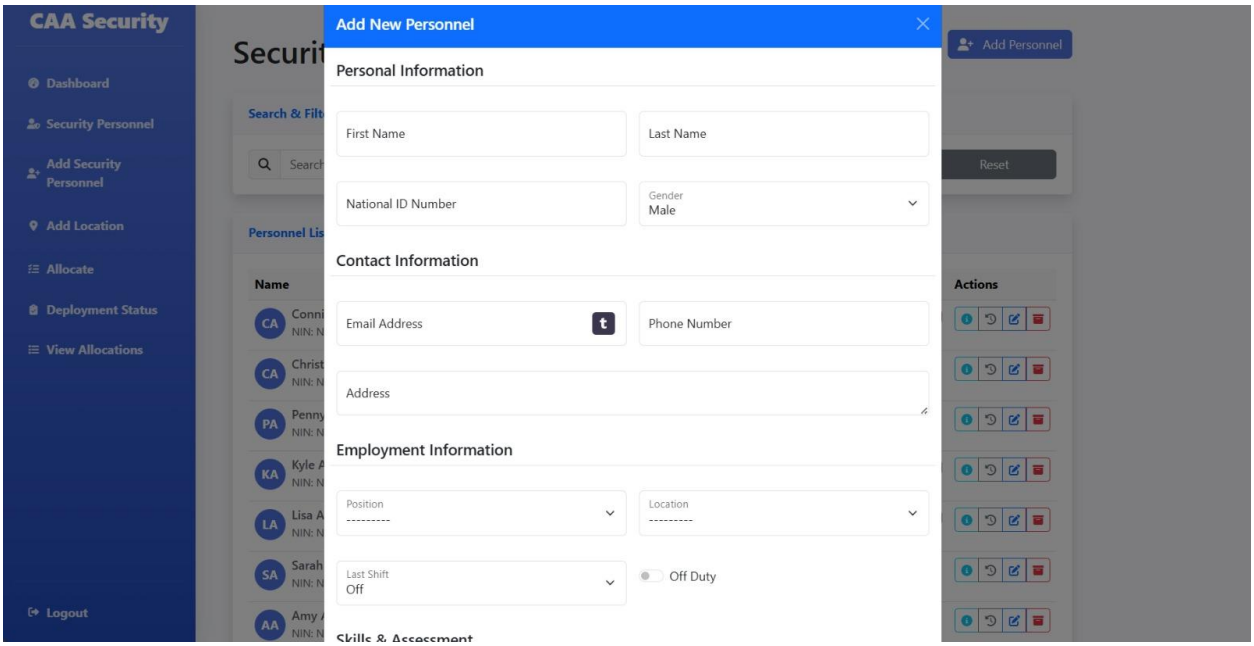

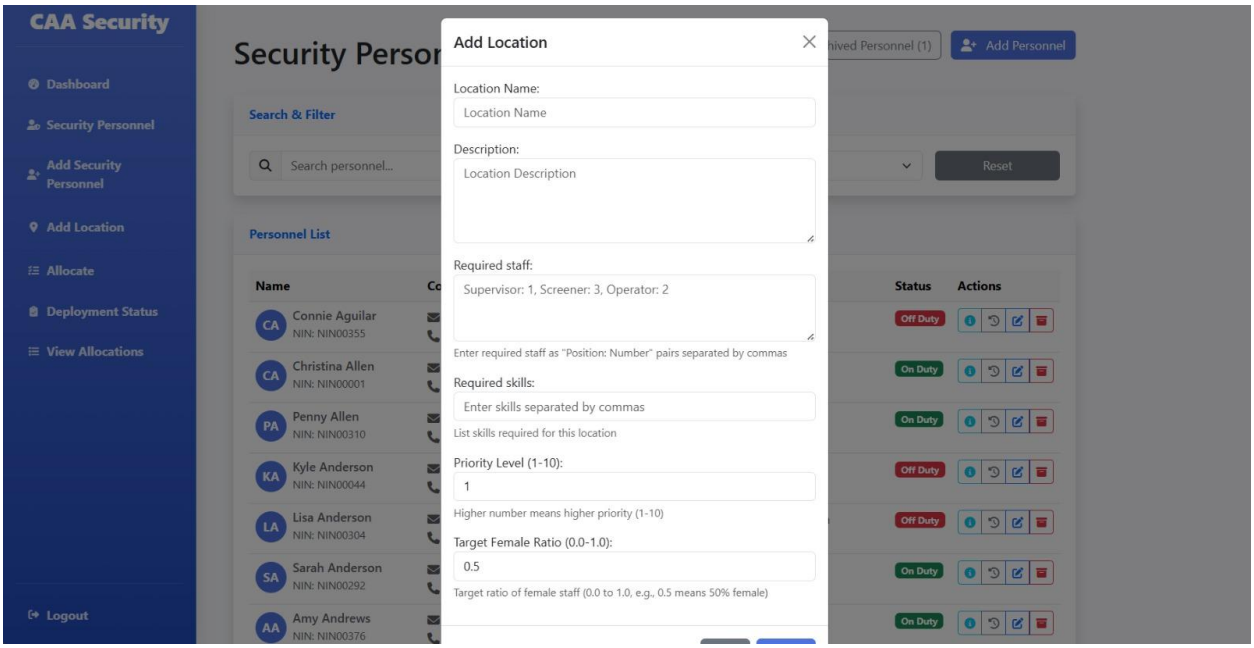

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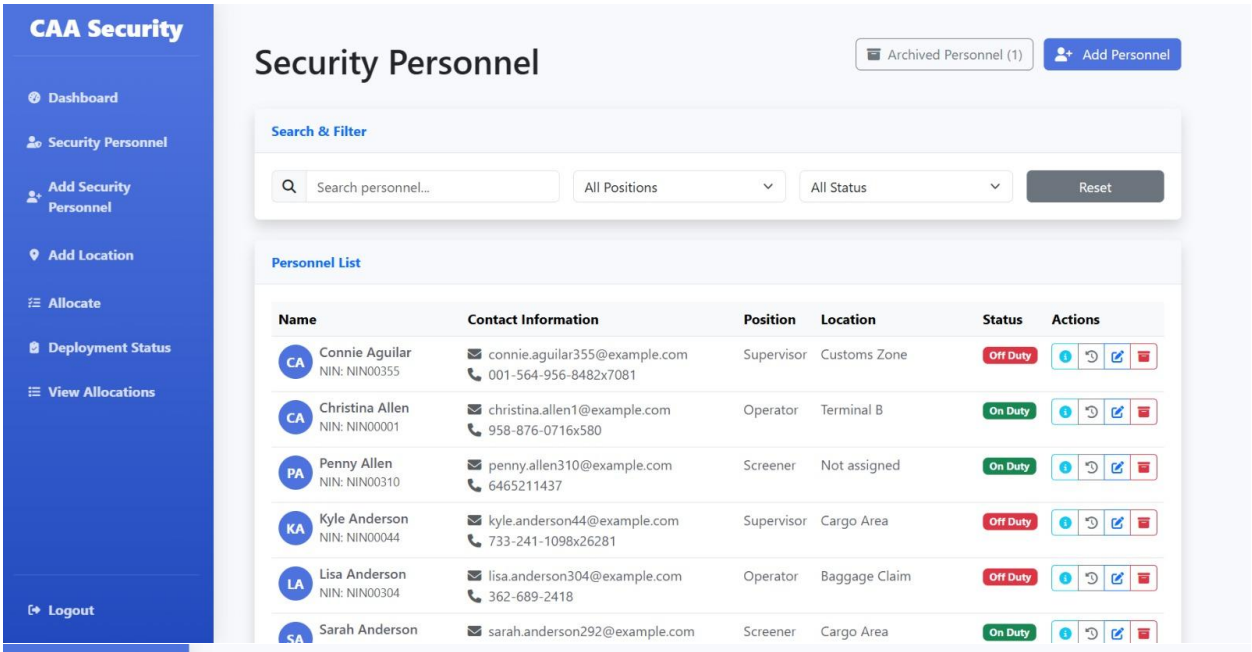

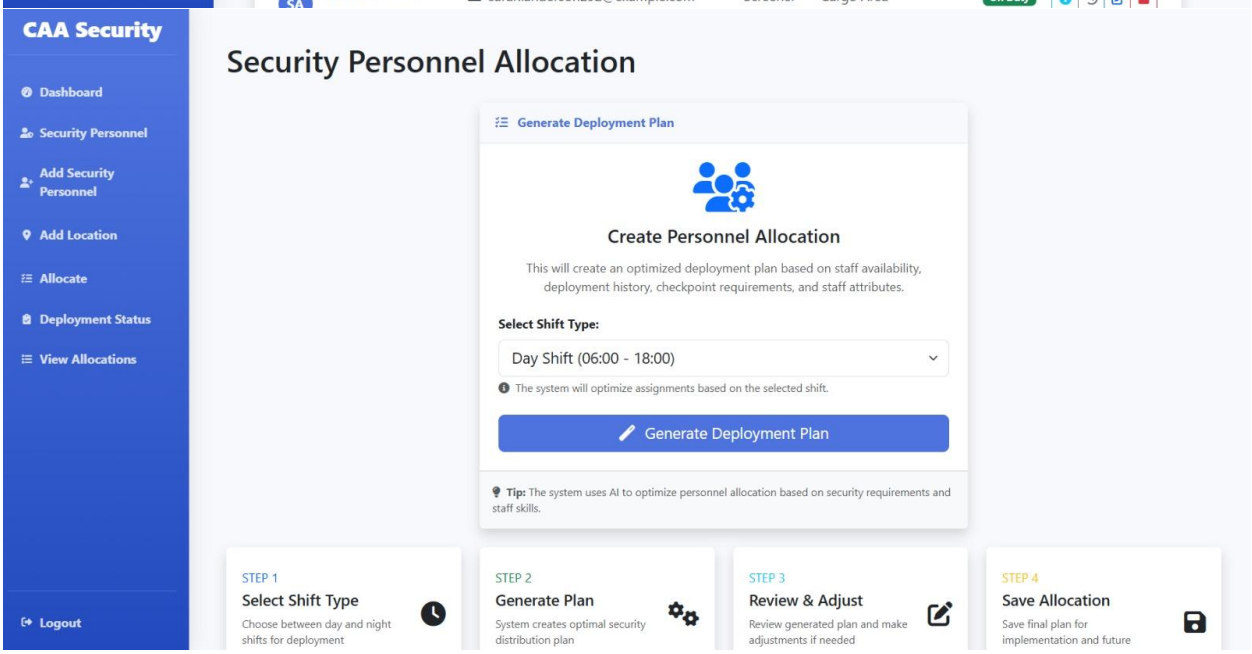

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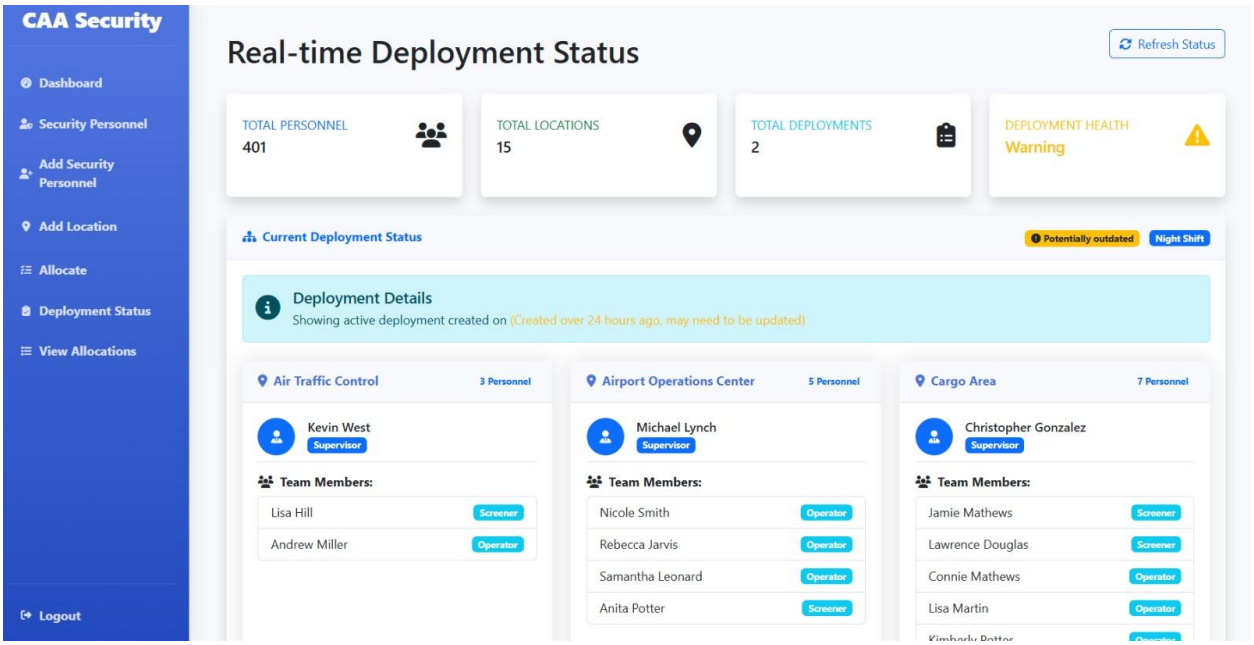

Purpose of Validation

The purpose of validating the Staff Deployment Management System (SDMS) is to ensure that the system meets its intended functional and non-functional requirements. Validation confirms that the system:

iii. Accurately captures staff deployment data.
iiii. Correctly allocates security personnel to shifts and posts.
iiiii. Handles emergency deployment scenarios.
iiiv. Produces reports for management decision-making.
iiv. Provides a user-friendly interface for administrators and staff.

Validation Method

The system was validated using the following methods:

Method	Description	Participants
Unit Testing	Each module (staff registration, deployment scheduling, report generation, notifications) was tested individually to ensure correct functionality.	Developer / Test Engineer
Integration Testing	Tested the interaction between modules to confirm that combined operations worked as expected.	Developer / Test Engineer
System Testing	Tested the complete system to ensure that it performs according to the design specifications.	Developer / Test Engineer
User Acceptance Testing (UAT)	Security department staff and management tested the system to ensure it meets operational needs. Feedback was collected.	Security Staff, Shift Supervisors, Admins
Validation with Real Data	The system was tested using actual staff records, schedules, and deployment scenarios from Entebbe International Airport.	Security Department

Conclusion

The study has successfully demonstrated that an ICT-based solution can significantly enhance the operational efficiency of staff deployment processes in the Aviation Security Department at Entebbe International Airport. The developed Staff Deployment Management System (SDMS) achieved the following:

i. Automation of manual processes: The system replaced time-consuming manual records with a centralized and digital solution, reducing administrative burden.
ii. Improved scheduling: It allowed for accurate, flexible, and fair staff shift and post assignments based on predefined parameters such as availability, duty history, and qualifications.
iii. Enhanced accountability and transparency: Audit trails, system logs, and role-based access controls

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ensured proper oversight and minimized human bias or errors.

iv. Better decision-making: With real-time data and reporting capabilities, supervisors can make informed and timely decisions regarding deployment.

Conclusively, the system is not only technically feasible but also practically beneficial. It contributes positively to the department's goal of maintaining high security standards by ensuring that qualified and adequately rested personnel are always deployed to critical points of operation.

Recommendations

Based on the system design, implementation, and evaluation, the following recommendations are provided for the effective utilization and future improvement of the Staff Deployment Management System:

Institutional Adoption and Support

The Aviation Security Department should formally adopt the system into its operational procedures. This includes issuing a policy directive to standardize its use across all units involved in staff deployment.

User Training and Change Management

Before full deployment, all relevant staff should undergo thorough training sessions to build confidence in using the system. A change management strategy should also be developed to ease the transition from the manual process to the automated system.

Routine Maintenance and System Upgrades

The system should be monitored regularly to identify bugs or performance issues. Planned updates and enhancements should be scheduled to incorporate user feedback, address emerging needs, and ensure long-term sustainability.

Integration with Existing HR and Payroll Systems

To maximize efficiency, the SDMS should be integrated with existing Human Resource Information Systems (HRIS) and payroll systems at the airport. This would ensure seamless flow of data related to attendance, overtime calculations, and performance tracking.

Enhancement of Security Features

Given the sensitive nature of aviation security, it is essential to continuously improve the system's security by incorporating features such as biometric login, multi-factor authentication, and role-based encryption for critical data.

Future System Expansion

In the future, the system could be enhanced to include:

i. A mobile application for on-the-go access by supervisors and staff.

ii. Automated alerts and notifications for shift changes or emergencies.

iii. Integration with biometric attendance systems for real-time monitoring of staff check-ins and check-outs.

iv. Performance analytics tools to track individual staff deployment patterns, punctuality, and workload.

List of Abbreviations

API	Application Programming Interface
AVSEC	Aviation Security Service
CAA	Civil Aviation Authority
CASSOA	Civil Aviation Safety and Security Oversight Agency
CSS	Cascading Style Sheets
DOM	Document Object Model
EIA	ENTEBBE INTERNATIONAL AIRPORT
ERD	Entity Relationship Diagram
HTML	Hypertext Markup Language
MVC	Model–view–controller
SQL	Structured Query Language

Source of Funding

This study did not receive any specific funding

Conflict of Interest

The authors declare no conflict of interest

Author Contributions

Josephine Nyonyozi conceived the study, conducted the literature review, collected and analyzed the data, designed and implemented the Staff Deployment Management System, and prepared the original manuscript. Aloysius Ssenteza supervised the research, provided technical and academic guidance throughout the study, reviewed the methodology and system design, critically revised the manuscript for intellectual content, and approved the final version for publication. Both authors read and approved the final manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to the sensitive nature of aviation security information and institutional confidentiality requirements, some datasets are not publicly available.

Ethical Approval

Ethical approval and permission to conduct this study were obtained through the University of Kisubi before data collection commenced. Additional authorization was

granted by the Aviation Security Department at Entebbe International Airport. The study adhered to accepted ethical principles, including confidentiality, privacy, voluntary participation, integrity, and responsible handling of all research data.

Informed Consent

Written informed consent was obtained from all participants prior to their involvement in the study.

Author Biography

Josephine Nyonyozi is a researcher in Information Technology with an interest in information systems development, business process automation, and digital transformation within critical infrastructure environments. Her research focuses on the design and implementation of technology-driven solutions that improve organizational efficiency, security, and service delivery.

Aloysius Ssenteza is an academic and research supervisor at the University of Kisubi with expertise in information systems, software engineering, and information and communication technology.

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